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Main directions of improvement of the method for calculation of idle time of cars at technical stations

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Abstract

The article is devoted to comparison of the existing and improved method of calculating the idle time of cars at technical stations. The positive and negative sides of that method are considered. In the analysis result, the main factors influencing the finding time of the cars at the technical station were revealed: the level of technical equipment, organizational structure, technology and organization of operations at the station, the volumes of train and shunting operations, the degree of unevenness of the arrival of train cars and trains. Currently on the Latvian Railway, the idle time of train cars under technological and cargo operations are actually determined from the moment of arrival at the station before moment of the departure from it. Thus, the existing method of calculating the idle time of train cars at technical stations does not foresee the prediction of this indicator and an assessment of the impact of innovations of a technical, technological and organizational nature. The article suggests the main directions of improving of the method for calculating the idle time of train cars by allowing us to take into full consideration the technical equipment, the technology of operations and the unevenness of the arrival of train cars to the technical station.

Keywords: Idle time of cars; Technical station; Technological operations; Unevenness of the arrival of cars

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1. Introduction

For any technical station involved in the process of freight transportation by railway, it is important to evaluate its economic efficiency. The idle time of cars are one of the main and important indicators of the operation of station, - the increase which leads to economic losses.

Further improvement of the classical and modern computer methods and the introduction of innovative technologies in relation to the calculation of the idle time of cars at technical stations will make it possible to refine the idle time calculation. This indicator will have been accurately predict and evaluate depending on the technical equipment of the station, the technological and organizational process of the operation.

Thus, the task is to analyze all methods for the idle time calculation at technical stations, identify the advantages and disadvantages of existing methods, and propose the main directions for improving this method of calculation.

2. The main provisions and questions about the essence of idle time of cars at technical stations

The cars are idle at technical stations and cargo facilities when performing various technological operations, as well as waiting for them. Thus, there is the finding time of cars, which appears from the moment of arrival at the technical station until the car departure from this station. That time is called the idle time of cars. In fact, the idle time of cars at technical stations consists of two main components: Direct time under technological, shunting and cargo operations in the parks reception, departure and sorting park; Time in the waiting for these operations – the unproductive (inter-operation) idle time.

The duration of these operations does not depend on the amount of train and shunting work and therefore the technical equipment, the particular organizational structure, technology and organization of work at the station determine the technological time for each station. Therefore, when calculating the various options for organizing work, the car-hours costs for technological operations related to the first element in real time change slightly. The duration of waiting for the execution of technological operations for both the transit traffic and the processed traffic depends primarily on the car traffic size passing through this technical station, as well as its power and productivity.

Thus, in practice, the assessment of unproductive idle time associated with the expectation of operations is of great importance for determining of the idle time at a technical station. This additional idle time sometimes, constitute the significant proportion of the total idle time for transit car without processing and with processing. Therefore, at present there is the current task – to determine the unproductive idle time and take measures to reduce this value to a minimum.

3. Analysis of factors affecting the idle time at technical stations

Currently, there are many factors, which affect the amount of idle time at the technical stations. The main factors affecting the idle time of the car at the technical station: Technical equipment level for the technical station; Features of organization of operation; Volume of train and shunting work; Uneven approach of trains to the technical station.

The first factor is the technical equipment for the station. First, the throughput and processing capacity of the station depends on the level of technical equipment. Today, there are technical stations on the railway, the technical condition of which is physically and morally obsolete. As an example, this is Daugavpils marshalling station. At this station, about 70% of the station tracks have a useful track length that does not correspond to the standard length (850 m), which makes it difficult to receive and depart full-size freight trains and creates the additional shunting movements along the station tracks. This limiting factor reduces the throughput and processing capacity of the marshalling station.

At Daugavpils marshalling station, as well as at some other stations, the descending part of hump is equipped with manual pneumatic retarders. The hump assistant manages these retarders from the control panel, guided by experience and visually taking into account changes in speed. Therefore, the human factor is decisive in his work. As a result, it is very difficult to ensure the necessary and predetermined speed of rolling stock from the descending part of the hump and stop the group of cars in the right place on the sorting track. From this it follows that there is a need to strengthen the power of hump technical equipment the through the introduction of a new microprocessor hump automatic centralization system and the equipment of brake positions with new types of retarders, as well as fully automate the sorting of cars, which will increase the processing capacity of the hump. The new technology will reduce the hump interval, reduce the amount of shunting operations, reduce the time for disbandment and increase the productivity of employees.

The second factor is the features of organization of operation at technical stations. The emergence of new international border and transfer stations had been create the customs, border, health and other services. Thus, freight transported by railway across the customs border of any state is subject to customs control at border and transfer stations. In accordance with the rules [1] at border and transfer stations, the maximum duration of the inspection and registration of customs formalities should not exceed 4 hours, if no special inspection of the cargo is required.

In connection with this, additional customs clearance and control operations had been form. These operations are reflected in the technological graphs of processing loaded and empty transit trains without processing and with processing, which arrive from abroad or depart abroad.

For Daugavpils marshalling station, which is a transfer station, the norms of technological time of processing of loaded and empty transit trains without processing shows the following Table 1.

Table 1. Norms of technological time for processing of transit trains without processing.

Technological time for processing of freight train	Reception and departure of trains			
	In receiving-and-departure park		In passenger park “A”	
	From border	To border	From border	To border
Loaded transit trains	280 min	—— 240 min	341 min	——
Empty transit trains	——	130 min ——	——	191 min

The norms of technological time of processing of loaded and empty transit trains with processing are showed in the following Table 2.

Table 2. Norms of technological time for processing of transit trains with processing.

Technological time for processing of freight train	Reception of trains in receiving-and-departure park		Departure of trains from departure park “D”	
	In Latvia	From border	In Latvia	To border
Loaded transit trains	124 min	244 min	121 min	146 min
Empty transit trains	——	——	——	147 min

These data indicate a significant impact on the idle time of the car when processing a freight train in receiving parks. From Table 1 and Table 2, it can see that the greatest technological time for loaded transit trains, arriving from abroad and departing to abroad.

Therefore, it is often one of the problems arising in the carriage of freights in international traffic that is a long time for carrying out verification activities for freight that are under customs control. At present, at transfer station the checking of the freight train composition upon arrival from the border has been carry out in accordance with the technological scheme. It is not possible in the short term to view and verify large areas of freight trains and to carry out customs control at the transfer station, where reception and transfer of freights to other countries take place.

The next major factor is the amount of train and shunting work. At the technical stations, there is such regularity that with the increase in the volume of work there is the increase in unproductive idle time of the cars, since the number of arrivals of freight trains increases, and the technological processing time of these trains remains unchanged. Thus, the train processing pate increases, but the technological processing interval of train decreases, therefore the unproductive idle time of the cars increases.

It is difficult to organize evenly train and shunting work on the railway. Therefore, there is such a factor as the daily irregularity of the approach of trains to the technical station, which greatly influences the station processes. In this case, additional idle time of trains has been expected pending technological operations. As a result, there are failures in the station, which are especially noticeable with high loads and insufficient technical equipment. For example, when there is a condensation of freight trains, at this time it may be the shortage of the station tracks to receive these trains. As a result, these trains have been force to stand at the intermediate stations while waiting. Thus, during the condensed train reception, the reserve capacity and processing capacity of a technical station is fully used.

4. Review and analysis of existing methods for calculating idle time at the technical station

The methods for calculating for the idle time at technical stations have evolved over a long time. Currently, there are several methods for calculating of idle time (see Fig.1). The first graphic method for determining the idle time of cars at the station is the daily plan-schedule of statin operating. It is the graphic display of station processes of train and car displacement and performing technological operations with them. It allows you to identify the load of all station elements, determine the need for shunting and technical means, to organize the best conditions for interaction in the work of the main elements and between themselves, to ensure the lowest train delays [2].

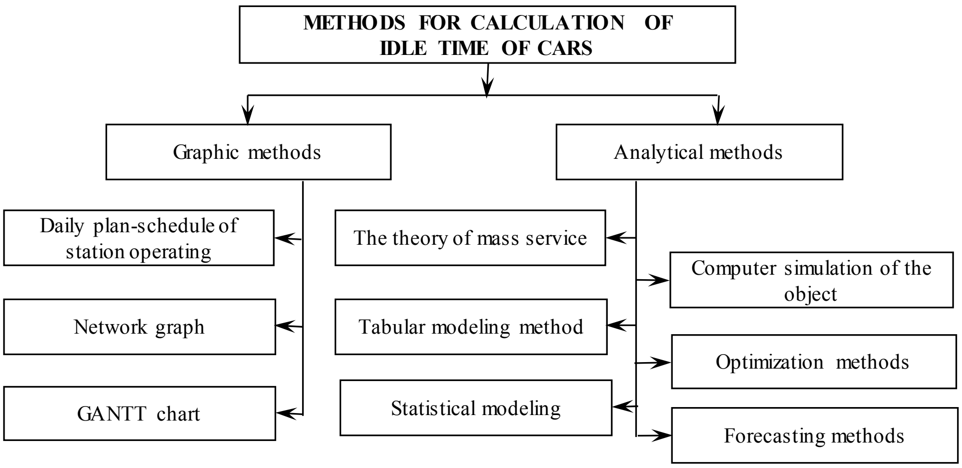

Fig. 1. Classification of methods for calculation of idle time of cars.

The disadvantage of the daily plan-schedule is the cumbersome and laboriousness of displaying of station processes, the limitation of the drawing sheet, not all station processes has been show on the graph. Its advantages are clarity and simplicity for understanding, when making this graph the knowledge of formulas are not necessary, the ability to take into account a number of factors without complicating the construction, which are taken into account very roughly or even are not taken into account in the analytical decision.

The second graphical method is the network graph, which is a dynamic model of the technological process, reflecting the technological dependence and sequence of the work, linking their completion in time, taking into account the cost of resources and the cost of work, while highlighting narrow (critical) places. The main goal of the network graph is to minimize the project duration [3]. The advantage of the network planning method is that the analysis of the critical path determines a separate complex task that must been complete on time, so that the work package as a whole is completed on time, and determines which tasks can be postponed temporarily, if necessary to reallocate resources for solving outstanding tasks. The disadvantage of the critical path analysis method is the not so obvious interrelation of tasks and time in the case of complex processes, since it is difficult to determine the critical path by operation number, the image and network understanding becomes more difficult as the scale of the graph increases.

One of the stages of preparation for planning station processes is the development of the Gantt chart. On the railway, technological graphs for processing trains of various categories at technical stations constitute a Gantt chart. The technological schedule represents the image of dependence of standard and planned expenses of processing time of trains and cars. It displays all sequentially related technological operations. With it, you can immediately determine the norms of time that is required for processing [4]. Its advantage, as well as the daily plan-schedule, is the clarity and simplicity of determining the technological time, as well as its construction. The disadvantage of this method is that given the dynamics of changes in the real situation, it is impossible to determine the accurate waiting time for the start of a technological operation, only its average value.

The first type of analytical method is the theory of mass service, which has been base on probabilistic models of service systems of various kinds, in which in random times there are requests for service and there are devices that ensure the fulfillment of these applications [5]. Analytical methods for solving problems of mass service has several advantages - these tasks are extremely diverse and allow the calculating, operational indicators of dependence on variable parameters. Disadvantages - with large loads of operating devices do not give results that are adequate to the actual conditions of their work, and also takes a lot of time to process statistical data (300-400 events), since the use of the queuing system method imposes a restriction on the flow of requests, it should be the simplest and it must be proved.

To determine the idle time of cars at technical stations, it has been propose to apply the method of tabular modeling. Its essence lies in the fact that the daily period has be divide into equal intervals. Then it is determined how many trains arrive for each such interval and the balance of trains at the end of this interval is determined. The sum of the residual compositions multiplied by the interval and has been divide by the number of compositions and the average idle time of composition in the park has been obtain [6]. The method is extremely cumbersome. To determine the dependence of idle time depending on the volume of the traffic, it is required to make calculations for 15–20 days. In the case of improvement of technology and changes in calculated intervals, this dependence should not been use and it is necessary to re-calculate the idle time for the upcoming period, taking into account the planned changes in the technology.

The method of statistical modeling is the collection and processing of data on the study object in order to obtain the statistical characteristics of the object, as well as the analysis of statistical materials. It should be take into account the unevenness of the day and the volume of work performed, and the duration of technological operations. Statistical modeling reflects the most significant operating conditions of real stations. To calculate the norms of idle time, the simulation period should be several days [7]. The main advantage of the statistical modeling method is the possibility of its application for complex technological processes in conditions of uncertainty, which does not require analytical models on which the computational methods are based. Statistical modeling makes it relatively easy to take into account the various laws of the distribution of idle time of cars and to describe and build models of systems of almost any complexity. The disadvantages of statistical methods are the need for a representative amount of data and a probabilistic assessment of the result.

One of the analytical methods for calculating of idle time is the forecasting method, which has been dividing into two types - intuitive and formalized. Intuitive methods are too simple and based on a probabilistic approach, which gives an unreliable result. The Formalized forecasting methods has been base on the construction of forecasts by the formal means of mathematical theory, which can improve the authenticity and accuracy of forecasts.

The optimization models are models whose goal is to find the best (optimal) criterion for the existing technology of the station [8]. The disadvantage is the difficulty of finding optimal solutions. Transport systems are very complex in structure, which is not always amenable to formalization. Therefore, all optimization decisions in the study of complex systems have application in the support systems of acceptance of decision. The simulation is a logical-mathematical description of the study object that should been use for the purpose of analyzing and evaluating the object being studied [9].

The advantages of simulation allow one to put forward a hypothesis about the law of distribution of the general population, applying the criteria of Pearson and Kolmogorov's agreement, and to obtain an adequate object model taking into account the flexibility of variation, reproduce the structure, algorithm and functioning and parameters of the system. This makes the simulation model more accurate, and the predictions on its basis are more definite. The simulation makes it possible to determine rational values of the parameters of the system under consideration, changing the process conditions and random events, the inclusion of which with traditional approaches causes the complexity of creating a model and conducting experiments, as well as processing their results.

Thus, each method of calculating the idle time of cars has its own advantages and disadvantages. Table 3 shows a comparative characteristic of methods for calculation of idle time of cars. It can be concluded that to improve the method of calculating idle cars, an integrated approach is needed to the calculation of the finding time of cars at a technical station, which will make it possible to obtain a new method of calculation. In the literature source [9] is said that of all the methods, simulation modeling allows more precisely to determinate the idle time of the car, and in the second place, the graph-analytical method is the construction of a daily plan-schedule of the station operating. Simulation has the advantage - the lack of a universal methodology and rules, so the process of creating of each new model is in many ways universal. When creating the model, the execution times of technological operations are formed using random laws. Thus, the technological time is reliable only with a certain probability, given before the start of statistical data processing. Therefore, it is proposed the instead of random laws to apply the mathematical model of the daily plan-schedule of the station operating.

5. The main directions of improving the method of calculation of idle time

At the present stage of development of railway transport, the improvement of the method for calculation of idle time at technical stations on the basis of the introduction of the new information and control systems is of great importance.

Now, in rail transport in the CIS countries and the Baltic States, the Unified System of Automated Account, the Analysis of Use and Regulation of Carload Park under Numbers of Cars (DISPARK) is successfully and actively developing. With the introduction of the DISPARK automated system, the accounting of the finding time of cars at technical stations is kept in the data-processing center of railway. With the help of this automated system, the calculation of idle time under cargo and technical operations at the technical stations is carried out in the numerical way; - it is the determination of the time spent at the station for any car from the moment of its arrival to the time of departure from the same station. This automated system, DISPARK, calculates the main performance indicators not by using mathematical formulas that have large inaccuracies, but calculates on base of the real information about all operations with the cars and accordingly provides an accurate and objective assessment of indicators [10].

Table 3. Comparative characteristic of methods for calculating of idle time.

Methods for calculating of idle time of cars	Comparative characteristic of methods for calculating											
				Time								
	Visibility	Difficulty and bulkiness	Train and shunting routes	Technological operations	Waiting	Accumulation of cars	Irregularity	Reflection of dynamic processes	Reflection of random processes	Big collection of statistics	Multivariate solutions	Forecasting and evaluation of indicators
Graphic methods												
Daily plan-schedule	+	+	+	+	+	+	+	-	-	-	-	-
Network graph	+	-	-	+	-	-	-	+	-	-	+	-
GANTT chart	+	-	-	+	-	-	-	-	-	-	-	-
Analytical methods												
The theory of mass service	-	-	-	+	+	+	+	+	+	+	+	+
Tabular modeling method	-	+	-	+	+	+	-	-	-	+	-	+
Statistical modeling	-	-	-	+	+	+	+	+	+	+	-	+
Formal forecasting method	-	-	-	+	+	+	-	+	+	-	-	+
Optimization methods	-	+	-	+	+	+	+	+	+	-	+	+
Simulation modeling	+	+	+	+	+	+	+	+	+	-	+	+

Note: “+” - the method has the characteristic; “-”- the method has no the characteristic

Thus, the DISPARK automated system is considered the information system that automates the collection of information and displays the train situation, but does not predict the performance.

Simulation is widely used to predict the station performance. The simulation system ISTRA, which is focused on research and optimization of large transport facilities in conjunction with production. This system allows you to assess the technological process and then choose the optimal mode of operation of this station. Using the ISTRA simulation system, any technology of station operating and the various technical devices can be represented as a set of logical and bunker elements with the parameters of their work, recorded in a certain sequence.

The times of technological operations can be determined by a deterministic schedule or can be formed using the random laws. After constructing a simulation model, it is possible to obtain accurate results of station performance. This proves the absolute superiority of simulation to other existing methods for calculation of idle time [11]. But despite this advantage over other methods for calculation of idle time, simulation modeling has so far not become the main method of calculation in practical work. Practice shows that the modeling process is very the bulkiness and time consuming, as well as special knowledge of programming in the simulation environment AnyLogic is necessary.

At present, existing methods for calculation of idle time at technical stations (an exception is simulation modeling) do not allow to determine the exact predicted time spent by cars, taking into account such factors as technical equipment, technology and organization of the station, the uneven receipt of trains at technical stations.

If we consider the authenticity and accuracy of the calculation of all existing methods, then after simulation, the second place is taken by the daily plan-schedule of the station operating [11]. The main directions of improvement of methods for calculation of idle time can be formulated:

- Using the train schedule and the plan for the formation of freight trains, you can create the mathematical model in the form of a daily plan-schedule of the station operating
- When formalizing the daily plan-schedule, take into account not only the technological operations of processing trains, but all the shunting movements along the yard necks that are associated with coupling and uncoupling of the train locomotive, disbanding and forming freight trains
- With the help of a mathematical model, it will be possible to obtain the station's performance indicators by changing the data of the train schedule and the formation plan for freight trains, elements of station technical equipment, technology of station operating, as well as taking into account changes in the workload and irregularity of trains entering the station
- The use of intelligent technologies for the collection and analysis of technological data, the widespread introduction of the support systems of acceptance of decision by operational personnel

6. Conclusion

As a result of the study, the constituent elements of the idle time of cars at a technical station were considered. It is concluded that special attention should be paid to unproductive idle time of cars. This time mainly depends on such factors as the level of technical equipment of the station, particular organization of operation, the volume of train and shunting work, and the degree of unevenness of the approach of trains to the technical station.

The main methods for calculation of idle time of cars at the technical station has been analyzed and reviewed. Of all the existing methods, simulation modeling turned out to be the most accurate, but in spite of this, it has the number of disadvantages – creating the simulation model requires a lot of work, as well as special programming skills. The paper proposes to consider the option of replacing the graphical construction of the daily plan-schedule with the analytical expression that will allow us to define the idle time of cars at the station without constructing a visual drawing, taking into account all the influencing factors on the idle time.

Thus, it was proposed to formally describe the sequence of technological operations, as well as all train and shunting movements at the station, which will allow us to find more accurately predict the idle time of cars at technical stations.

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